HealthHazard® Evaluation Program

Evaluation of Silica Exposures During Micro Trenching

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Centers for Disease Control and Prevention
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Disclaimer

The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 (29 U.S.C. § 669(a)(6)). The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations (42 CFR Part 85).

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Introduction

Request

Management from a communications company requested a health hazard evaluation concerning employee exposure to respirable crystalline silica during micro trenching activities.

Workplace

The work took place outdoors in a residential neighborhood. Each project performed by this company occurs in a different outdoor location. The length of the project depends upon the scope of work. Eight employees were selected from the crew for the evaluation based on their job tasks. No employees belonged to a union. During our visit, the crew worked a single shift that was approximately eight hours long. The length of the shift could change depending on the project.

During a given workday, employees performed tasks that included cutting the micro trench, installing the cable, emptying the vacuum truck, filling the micro trench, and loading the dumpster.

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

We visited the work location once, over a three-day period, in January 2019. During our visit, we did the following activities:

- Observed work processes and work practices.
- Collected air samples for respirable crystalline silica and respirable dust.
- Collected bulk samples of the material being cut to determine its silica content.
- Measured the air velocity in the vacuum hose.
- Used a portable weather station to record information about temperature, relative humidity, and wind speed and direction.

To learn more about our methods, go to Section B in the Supporting Technical Information

Our Key Findings

The vacuum truck appeared to control exposures

- We did not detect respirable crystalline silica in any of our air samples. We did detect low levels of respirable dust (range: not detected–81 micrograms per cubic meter of air).

Emptying the vacuum and loading the dumpster produced the most dust

- When employees emptied the vacuum, it sometimes created visible dust clouds around them. The dust clouds were larger when hand tools were used to empty the vacuum or when the vacuum filters were manually cleaned because these tasks increased the disturbance of the spoils (vacuum content).
- When employees loaded spoils into the dumpster, it created a visible cloud of dust around them. Those employees were unable to stay upwind while loading the dumpster. While the wind direction was relatively constant, the dumpster was loaded from both sides to ensure even loading.

Compliance with health and safety programs needs improvement

- Employees were not wearing their respirators correctly, and they appeared to be unsure about proper donning and doffing techniques. Some employees had facial hair and said they did not recall being fit tested.
- Hearing protection was not available or used. The drivable saw and vacuum truck produced noise that appeared to NIOSH project officers to be above recommended levels.

To learn more about our results, go to Section B in the Supporting Technical Information

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Benefits of Improving Workplace Health and Safety:

↑ Improved employee health and well-being	↑ Improved image and reputation
↑ Better workplace morale	↑ Better products, processes, and services
↑ Better employee recruiting and retention	↑ Could increase overall cost savings

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls: https://www.cdc.gov/niosh/topics/hierarchy/.

We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in "Recommended Practices for Safety and Health Programs": https://www.osha.gov/shpguidelines/index.html.

Recommendation 1: Reduce employees' potential for exposure to respirable dust

Why? Standard operating procedures and respiratory protection programs are important parts of reducing potential exposures. The company has determined that respirators are required for certain tasks. Therefore, additional regulatory requirements are also required to ensure compliance with the respiratory protection standard.

Even though our exposure measurements for dust were low (range: not detected–81 micrograms per cubic meter of air), opportunities existed to reduce potential exposure to respirable dust. We observed that emptying the vacuum and loading the dumpster produced visible clouds of dust, and sometimes employees did not wear their respirators correctly. Additionally, more respirable crystalline silica may be present in the dust in work situations different from those we sampled in this evaluation. Occupational exposures to respirable crystalline silica have been associated with silicosis, lung cancer, pulmonary tuberculosis disease, and other airway diseases.

How? At your workplace, we recommend these specific actions:

Improve the existing respiratory protection program.

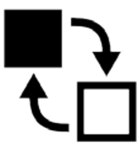
- Ensure that you are in compliance with the Occupational Safety and Health Administration (OSHA) respiratory protection standard, 29 CFR 1910.134: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=12716.
- Write a program documenting worksite-specific procedures that require respirator use as well as identify a competent program administrator. 29 CFR 1910.134(c) lays out all the requirements for your written program. This includes annual fit testing, documented training, and medical clearance, among other things.
- Consider contacting the OSHA consultation program for assistance with developing your respiratory protection program (https://www.osha.gov/dcsp/smallbusiness/consult.html).
- Ensure that employees have access to respirators and are trained on their use. Do not allow facial hair for employees using respirators; facial hair can interfere with the sealing surface of respirators.

Establish clear guidelines for when to empty the vacuum.

- Emptying the vacuum more often should prevent the need for excessive cleaning of the filters in the vacuum system. It could also potentially reduce the frequency of hose clogs.

Clean the vacuum truck filter with a high efficiency particulate air (HEPA) filtered vacuum.

- Dropping the filters on the ground created a cloud of dust around the employee and could potentially damage the filter. Using a vacuum will lessen the size of the dust cloud produced while cleaning the filter and reduce the chance of damage.
- Consider contacting the vacuum manufacturer to explore alternatives, such as a shaker or a reverse air pulse, to reduce the frequency of filter cleaning.



Consider parking the dumpster so it can be loaded through its open tailgate with employees standing upwind, if possible.

- Loading the dumpster through the open tailgate would reduce the height from which the load was dumped, if the tailgate can be safely secured in the open position.
- Loading the dumpster so that employees are standing upwind of it would reduce the amount of dust exposure.

Recommendation 2: Address other health and safety issues we identified during our evaluation

Why? A workplace can have multiple health hazards that cause employee illness or injury. Similar to the ones identified above, these hazards can potentially cause serious health symptoms, lower morale and quality of life for your employees, and costs to your business. We saw the following potential issue at your workplace:

- Excessive noise around the saw and vacuum when both were operating together.

Although it was not the focus of our evaluation, this hazard could cause harm to your employees' health and safety and should be addressed.

How? At your workplace, we recommend these specific actions:

Create a hearing conservation program.

- Perform periodic noise monitoring to determine which job tasks require hearing protection.
- Train employees about the hazards of noise on the job.

- Instruct employees to recognize when hearing protection is required.
- Provide hearing protection in the interim to employees who work closely with the saw and vacuum while determining hearing protection requirements. Provide training to employees about proper use of hearing protection.

Supporting Technical Information

Evaluation of Silica Exposures During Micro Trenching

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Section A: Workplace Information

Workplace

The work took place outdoors in a residential neighborhood. Each project performed by this company occurs in a different outdoor location. The length of the project depends upon the scope of work.

Employee Information

- Eight employees were selected from the crew for the evaluation based on their job tasks. No employees belonged to a union.
- During our visit, the crew worked a single shift that was about eight hours long. The length of the shift could change depending on the project.

Process Description

While we were on-site, the job task was to cut micro trenches in the roadway to install communication cable (Figure 1). This process used the vacuum truck to capture dust. Earlier in the week, the company had employees cut what they called "laterals" into the sidewalk. Each lateral was a cut perpendicular to the street and would eventually connect the micro trench in the street to each property along the street. The laterals were cut with a drivable saw that did not utilize the vacuum truck, so small debris piles were at each cut location (Figure 2). We did not observe many laterals being cut during our visit. The crew cut the laterals earlier in the week in preparation for the micro trenching during our visit. We were able to watch one employee from a different crew cut a few laterals that were missed when the majority of laterals were cut earlier in the week.

Figure 1. Vacuum truck and drivable saw cutting the micro trench for the communication cable. There is an employee serving as a spotter behind the drivable saw. Photo by NIOSH.

Figure 2. A "lateral" is being cut into the sidewalk to connect the micro trench in the street with the property. The micro trench will be cut into the street after this task. Photo by NIOSH.

Micro Trenching and Cable Installation

Employees had the following job titles/tasks:

- Saw operator: this employee drove a drivable saw, guiding it while it was cutting the micro trench.
- Vacuum truck driver: this employee drove the vacuum truck that was attached to the drivable saw.
- Spotter: this employee walked behind the saw and was responsible for signaling the vacuum truck driver and for periodically checking the depth and width of the micro trench.
- Fiber optic cable installation: these employees put the fiber optic cable into the micro trench. One employee was responsible for quality assurance checks for each lateral cut that worked near this group.
- Debris cleanup: these employees picked up debris from different locations around the worksite. This task happened throughout the worksite (neighborhood) throughout the day.

Emptying the Vacuum Truck

The vacuum truck was emptied several times during the shift after it filled with debris (Figure 3). Employees from multiple job titles/tasks were responsible for emptying the vacuum truck. When the vacuum needed to be emptied, the vacuum truck driver, saw operator, spotter, and one or two other employees would drive the vacuum truck to a predetermined dumping area. The dumping area for the project we observed was at the end of a cul-de-sac and outside the cutting area.

Employees placed a plastic tarp on the ground prior to the first time the vacuum was emptied. The vacuum spoils (vacuum content) were emptied onto the tarp and a pile formed there throughout the day. The vacuum truck was backed up to the tarp and a hydraulic mechanism opened the main vacuum chamber and dumped the spoils onto the tarp. This process took anywhere from 5 to 25 minutes. Each time the vacuum was emptied, different levels of employee interaction were required with the spoils. At times, employees needed to use shovels to empty the filter compartments and or clean the filters. If the filters needed to be cleaned, employees removed the filters and banged them onto the ground from chest height in order to knock off dust that had built up around the filter.

Figure 3. Employees emptying the spoils from the vacuum truck. One of the filter housings (the small, black cylinder to the left of the large, orange cylinder) is open so that employees could empty it using a shovel. Photo by NIOSH.

Loading the Dumpster

One or two employees loaded the spoils pile on the tarp into the dumpster after cutting was done for the day (Figure 4). Employees used a mini skid steer to move the spoils into the dumpster. Spoils were scooped with the mini skid steer and then dumped into the dumpster from each side of the dumpster to ensure the dumpster was evenly loaded. When the pile was small enough, shovels were used to move the rest into the dumpster, along with the tarp.

Figure 4. Employees loading the pile of spoils into the dumpster using shovels and a mini skid steer. Both employees are wearing N95 respirators.

Filling in the Micro Trench

After lunch, most of the employees worked on filling in the micro trench that had been cut in the morning by pouring concrete into the micro trench with a drivable concrete mixer. Multiple employees walked behind the mixer and used shovels to scrape the excess concrete off the roadway.

Section B: Methods, Results, and Discussion

Methods: Observations of Work Processes, Practices, and Conditions

We evaluated the following during the course of our site visit:

- Work processes
- Personal protective equipment use (PPE)
- Workplace conditions

Results: Observations of Work Processes, Practices, and Conditions

- Employees were required to wear safety glasses, high visibility vests or jackets, boots, and hard hats at all times while working. Over time, we observed employees became less compliant with these policies. For example, by the third day of our visit, many employees were not wearing safety glasses.
- We were informed that hearing protection was not required. We noticed that it was very noisy around the saw and vacuum truck when both operated together. We did not measure noise during this evaluation, but it was difficult to communicate when we were standing near the operating saw. If you have to raise your voice to be heard 2–3 feet away, you should assume that the sound level is at or above 85 A-weighted decibels (dBA), which is when hearing conservation programs should be implemented [OSHA 2011].
- Employees were required to wear N95 filtering facepiece respirators while emptying the vacuum truck, which was done multiple times each day. Most employees had a respirator available. None of those who wore a respirator, wore it correctly: some wore only one strap (instead of both), some did not wear the respirator cup over both their nose and mouth, and some wore the respirator around their neck and not on their face. Some employees had facial hair or visible stubble. We also observed inconsistencies with when the respirators were donned. Sometimes, respirators were not donned until after the vacuum had begun to be emptied. We asked some employees about their experiences with fit testing, and they could not recall being fit tested for their respirators.
- How employees determined when to empty the vacuum was unclear. There are glass viewports in the vacuum hatch designed for seeing the level of debris in the vacuum, but they were caked with debris. Sometimes, the vacuum was emptied based on the work schedule (e.g., employees finished a section and adequate time has passed since the last empty) or loss of suction (e.g., at the discretion of the work crew).
- Employees used shovels and a mini skid steer when gathering debris around the job site. Employees shoveled the small piles created by each lateral cut into the bucket of the mini skid steer. They dumped this debris onto the pile of spoils on the tarp near the dumpster.

- Either one or two employees loaded the dumpster with the spoils once per day after all of the cutting was completed. Employees were required to wear N95 filtering facepiece respirators during this task. We observed similar issues with wearing respirators as those identified during the dumping of the vacuum truck.

Methods: Exposure Assessment

Air Sampling

We collected personal air samples on nine employees on Day 1 and eight employees on Days 2 and 3. We used three-piece, 37-millimeter diameter cassettes with 5-micrometer (µm) pore size polyvinyl chloride (PVC) filters. We used a Mesa Laboratories, Inc., Model GK2.69 high flow personal sampling cyclone, at a flow rate of 4.2 liters of air per minute.

- We analyzed each sample for respirable dust and respirable crystalline silica (RCS) using the National Institute for Occupational Safety and Health (NIOSH) Methods 0600 and 7500 with a tetrahydrofuran (THF) preparation [NIOSH 2019]. For time-weighted average (TWA) calculations, we used the limit of detection divided by the square root of 2 to replace non-detectable values.
- We removed the air samplers from employees during their lunch break and replaced them afterwards.

Weather

To capture weather parameters, we set up a Kestrel Instruments Model 4500 portable weather station, with data logging capabilities. The weather station logged information once per minute on a variety of parameters including wind speed and direction, temperature, and relative humidity. We moved the weather station as the crew moved through the streets during the workday.

Vacuum Airflow

We measured centerline velocity pressure by connecting tubing between the pressure ports of a TSI Incorporated, Model 9565, VelociCalc multi-function ventilation meter hot wire anemometer. We inserted a Dwyer Instruments, Inc. Series 160 stainless steel pitot tube, into a small hole drilled through the sidewall of the vacuum hose. The vacuum hose had a four-inch inner diameter. We used the velocity pressure measured by the anemometer and a 0.9 correction factor to calculate air velocity and flow through the vacuum hose. These measurements were taken at the beginning of the shift when the vacuum truck was empty, just before emptying the spoils from the vacuum, and immediately after emptying the spoils from the vacuum.

Bulk Samples

We collected bulk samples from different locations on different days. We wanted to determine the silica concentration in the substrate that was being cut with the saw and identify anything in those samples that would interfere with the analyses of the air samples.

Results: Exposure Assessment

Air Sampling

We did not detect RCS in any of the air samples. The average minimum detectable concentration for RCS was 7 micrograms of dust per cubic meter of air (µg/m^3) (range: 6–20). The range was reduced to 6–9 µg/m^3 when removing "fiber installation 1" from Day 1. There were problems with a sampling pump resulting in a loss of approximately 207 minutes of sampling time for that employee. Lost sampling time raises the minimum detectable concentration for those samples.

On Day 1, air samples for respirable dust ranged from not detected to 54 µg/m^3. On Day 2, air samples for respirable dust ranged from not detected to 81 µg/m^3. On Day 3, air samples for respirable dust ranged from not detected to 73 µg/m^3 (Table C1).

Weather

For the three days we sampled, average wind speed ranged from 0.3–0.8 meters per second. The average temperature ranged from 11°C–14°C (52°F–57°F). The average relative humidity ranged from 28%–94%.

On all three workdays, the orientation of the work crew changed over time as they made their way through the neighborhood. Thus, the direction of the wind relative to the employees was not constant and changed throughout the day.

Vacuum Airflow

We measured a centerline velocity pressure in the vacuum hose of 3.5 inches of water (inH_2O) at the beginning of the shift when the vacuum truck was empty, which corresponds to an airflow rate of 16.2 cubic meters per minute (m^3/min), equivalent to 573 cubic feet per minute (cfm) at 4°C (40°F). We measured a centerline velocity pressure of 2.3 inH_2O just before the spoils from the vacuum were dumped, which corresponds to an airflow rate of 13.1 m^3/min (463 cfm). We measured a centerline velocity pressure of 3.6 inH_2O immediately after the spoils were dumped from the vacuum, which corresponds to an airflow rate of 16.5 m^3/min (581 cfm). The vacuum excavator used during this study was a DitchWitch Model FX65 with a rated airflow of 34.4 m^3/min (1,215 cfm).

Bulk Samples

We took six bulk samples from a variety of locations including different cuts (e.g., cross cut and curb cut) and from the pile of spoils that came out of the vacuum. The bulk samples contained between 5.5% and 26% quartz, averaging 13% (Table C2).

Discussion

We did not detect any RCS in the personal air samples we collected. The percentage of silica in the spoils was generally lower than found in studies of silica exposures during asphalt milling [NIOSH 2013, 2014]. Vacuum airflow was less than half of the rated airflow of 1,215 cfm. However, our measurements were taken with the full length of vacuum hose as it was used during the evaluated micro trenching. Rated airflow measurements with less vacuum hose length, which reduced pressure losses, may result in higher airflow readings.

The dustiest tasks involved emptying the vacuum and loading the dumpster. The mechanical actions of dumping the spoils from the vacuum, dropping the filters on the ground, and shoveling the spoils into the dumpster contributed to visible dust clouds around employees as they performed those tasks. Although they were required to wear respiratory protection during these tasks, protection from potential exposures depends on reliable and correct use of PPE. We observed employees wearing respirators incorrectly or not donning respirators during these tasks, which could contribute to potential exposures to RCS.

The dumpster needed to be loaded from both sides to ensure an even load, so it was impossible for employees to stay upwind during this task, as was current policy. The high walls of the dumpster prevented the mini skid steer from loading from a single side and required the spoils to be dropped into the dumpster from a height.

Limitations

This evaluation is subject to several limitations. First, industrial hygiene sampling can only document exposures on the days of sampling in the locations sampled. These results may not be representative of conditions during other days. Second, the small size and homogenous nature of the population sampled limit the generalizability of our evaluation results. Finally, we were not able to capture potential exposures from the lateral cuts because the majority of them were not performed while we were on-site.

Conclusions

Although we did not detect RCS in any of our air samples, we found that compliance with the respiratory protect program could be enhanced, and we recommended improvements. We also recommended that the company explore other methods for loading the dumpster and cleaning the vacuum filter because these tasks caused the most dust, and potentially, the greatest risk of exposures. During our evaluation, we observed a possible issue with excessive noise exposure that we recommended the company investigate further.

Section C: Tables

Table C1. Full shift personal air sample results for respirable dust (µg/m³)

Job title	Sample duration (minutes)	Respirable dust concentration	Minimum detectable concentration	Minimum quantifiable concentration
Day 1				
Saw operator	341	Not detected	30	74
Vacuum truck driver	292	Not detected	30	86
Spotter	331	Not detected	30	76
Fiber installation 1	135*	Not detected	70	190
Fiber installation 2	339	[54]	30	74
Fiber installation 3	343	Not detected	30	73
Fiber installation 4	283	[49]	30	89
Debris cleanup	331	Not detected	30	76
QC fiber installation	203	Not detected	20	62
Day 2				
Saw operator	376	[55]	30	66
Vacuum truck driver	312	Not detected	30	80
Spotter	374	[42]	30	67
Fiber installation 1	332	78	30	76
Fiber installation 2	346	81	30	73
Fiber installation 3	349	Not detected	30	72
Fiber installation 4	270	[69]	40	94
Debris cleanup	358	71	30	70
Day 3				
Saw operator	176	Not detected	30	71
Vacuum truck driver	176	[46]	30	71
Spotter	174	73	30	71
Fiber installation 1	177	[32]	30	71
Fiber installation 2	174	[46]	30	72
Fiber installation 3	177	[32]	30	71
Fiber installation 4	173	[33]	30	73
Debris cleanup	181	Not detected	30	69

[ ] = Values shown in brackets are between the minimum detectable and minimum quantifiable concentrations for this sample set. More uncertainty is associated with these concentrations.

*There were problems with this sampling pump resulting in a loss of approximately 207 minutes of sampling time, raising the minimum detectable concentration.

Table C2. Percent quartz detected in bulk samples

Sample location	% Quartz
Cul-de-sac saw pile	5.5
Cross cut	5.8
Vacuum spoils	10
Main road saw pile	12
Curb cut	16
Asphalt pavement	26

Section D: Occupational Exposure Limits

NIOSH investigators refer to mandatory (legally enforceable) and recommended occupational exposure limits (OELs) for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects.

However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a preexisting medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- OSHA, an agency of the U.S. Department of Labor, publishes permissible exposure limits [29 CFR 1910 for general industry; 29 CFR 1926 for construction industry; and 29 CFR 1917 for maritime industry] called PELs. These legal limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2007]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States include the threshold limit values or TLVs, which are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2019].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA (Public Law 91-596) requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions.

Respirable Crystalline Silica

Silica, or silicon dioxide, occurs in a crystalline or noncrystalline (amorphous) form. In crystalline silica, the silicon dioxide molecules are oriented in a fixed pattern versus the random arrangement of the amorphous form. The more common crystalline forms in workplace environments are quartz and cristobalite, and to a lesser extent, tridymite. Occupational exposures to RCS (quartz and cristobalite) have been associated with silicosis, lung cancer, pulmonary tuberculosis disease and other airway diseases, kidney disease, and autoimmune disorders.

Silicosis is an irreversible but preventable fibrotic disease of the lung caused by the deposition of fine crystalline silica particles in the lungs. Silicosis is caused by the inhalation and deposition of crystalline silica particles that are 10 μm or less in diameter. Particles 10 μm and smaller are considered respirable particles and have the potential to reach the lower portions of the human lung (alveolar region). Although particle sizes 10 μm and smaller are considered respirable, some of these particles can be deposited before they reach the alveolar region [Hinds 1999].

Symptoms of silicosis usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illnesses. Silicosis usually occurs after years of exposure (chronic), but may appear in a shorter period of time (acute) if exposure concentrations are very high. Acute silicosis is typically associated with a history of high exposures from tasks that produce small particles of airborne dust with a high silica content [NIOSH 1986]. Even though the carcinogenicity of crystalline silica in humans has been strongly debated in the scientific community, the International Agency for Research on Cancer (IARC) in 1996 concluded that there was "sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources" [IARC 1997]. Several other serious diseases from occupational exposure to crystalline silica include lung cancer and noncarcinogenic disorders such as immunologic disorders and autoimmune diseases, rheumatoid arthritis, renal diseases, and an increased risk of developing tuberculosis disease after exposure to the infectious agent [NIOSH 2002].

When proper practices are not followed or controls are not maintained, RCS exposures can exceed the OSHA PEL, NIOSH REL, or the ACGIH TLV. The OSHA PEL and NIOSH REL for RCS are both 50 ug/m^3 [NIOSH 2007, OSHA 2016]. The ACGIH TLV for quartz is 25 $\mu g/m^3$ as an 8-hour TWA [ACGIH 2019].

Section E: References

Discussion

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Occupational Exposure Limits

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